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Summary of On-Scene-Coordinator Protocol for Contaminated Underwater Operations

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SUMMARY OF ON-SCENE-COORDINATOR PROTOCOL FOR CONTAMINATED UNDERWATER OPERATIONS[1]

by

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16. ABSTRACT

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The EPA, recognizing the need to assess, modify, and evaluate procedures and equipment applicable to working in contaminated underwater environments, entered into an interagency agreement with NOAA. As part of this work, an "Interim Protocol on Underwater Operations" was developed and is the subject of this paper.

The Protocol was based upon preliminary field evaluations of diving equipment in controlled chemical underwater environments. Following a peer review of the document by the user community, the methods, procedures, equipment, and training will be applied at a number of sites or spills of opportunities. The resulting information will be utilized to prepare a "Manual of Practice (MOP) on Underwater Operations in Contaminated Waters." The final MOP is scheduled for publication in December 1984.

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INTRODUCTION

A review of current requirements of various civilian, government and military agencies such as the U.S. Environmental Protection Agency (EPA), U.S. Coast Guard (USCG), National Oceanographic Atmospheric Administration (NOAA), U.S. Navy (USN), and clearly indicates a need for response activities involving underwater chemical release incidents. Situations such as damage assessment of leaking vessels and/or pipelines, location of underwater sources of contamination, containment/cleanup of sunken pollutants, environmental assessment and evaluation of cleanup operations, recovery of containers/contents of containers, repair/maintenance of underwater equipment and structures to prevent discharges, research studies, and other activities, at times require that divers enter contaminated environments. Unfortunately, there is very limited capability available to enter these environments safely to perform the necessary tasks. Attempts have often resulted in injuries,

primarily chemical burns, to divers and/or surface support personnel handling contaminated equipment. Little information is available on low-level exposure of diving personnel to chemicals; only acute or immediate effects have been reported. Chronic, long-term toxicity is only now being addressed by several government agencies.

Equipment problems in chemically contaminated water environments, primarily due to petroleum products, is well documented. Divers entering these environments have often experienced equipment failure/deterioration. This is not only costly but, even more serious, can be life threatening. Equipment deterioration has been responsible for at least one fatality (2) and is responsible for many incidents of diver exposure to contaminants.

The use of remotely operated vehicles (ROV) in response to chemical release situations has also been very limited. ROV's may be able to contribute significantly by allowing certain underwater activities to be performed without having to risk placing a diver in the water. However, the current state-of-the-art on ROV's limits their use to inspection and evaluation of underwater conditions to determine whether or not a diver is necessary. If diving is necessary, ROV's can be utilized to increase the safety and effectiveness of the diver while in these environments. Underwater visibility and entanglement are the two most serious drawbacks to effective use of ROV's in these situations (2). As ROV technology develops, there will probably be more varied and reliable uses of these vehicles in spill-response situations.

Because divers must continue to work in chemically contaminated waters, more appropriate procedures and equipment are required to safeguard their health and welfare. In addition, because no procedure or equipment is fool-proof during diving operations, divers should be warned against diving in waters containing particularly toxic substance.

Recognizing the needs in this area, the U.S. EPA and NOAA entered into an Interagency Agreement to improve and update safety capabilities involving underwater hazardous chemical cleanup responses. The work which started in August 1981 includes the assessment, testing, evaluation, and demonstration of commercial underwater protective suits, clothing, support equipment, and breathing apparatus in waters contaminated with substances that may be injurious to a diver's health.

Under the IAG, a workshop/seminar entitled "Protection of Divers in Waterways Receiving Hazardous Chemical, Pathogenic and Radioactive Substances Discharges," was held by the Undersea Medical Society (UMS), Bethesda, MD, on November 9-11, 1982 and the proceedings from this workshop are now available by contacting UMS (3). The unanimous conclusions of this meeting were: (a) no alternative currently exists for use as a substitute for divers working in hazardous environments, and (b) research and development is needed to modify commercially available diving dress and helmet assemblies to protect divers from hazardously contaminated environments.

As part of this work, an Interim Protocol has been prepared based on preliminary field evaluations of diving dress and equipment in controlled chemically contaminated underwater environments. In summary, the Protocol provides information on (a) evaluating hazards depending on the nature of substances present ("Go/No-Go" situations to determine whether diving is

possible or not), (b) "when" and "how" to use divers in hazardous environments, (c) medical and physiological implications of a diver's exposure, (d) state-of-the-art protection for diving and surface support personnel when performing underwater tasks in contaminated waters, and (e) decontamination operations for diving personnel and equipment.

Subsequent to a review and field evaluation of the Interim Protocol, and demonstration of modified equipment and response procedures, a Manual of Practice (MOP) will be developed to provide guidance to agencies that use divers in waters of questionable environmental quality. It must be noted that the Interim Protocol as well as the MOP are intended for guidance purposes only.

DIVING MODES AND EQUIPMENT

There are two basic diving modes: (1) one atmosphere diving and (2) ambient diving.

In one atmosphere diving, the diver is encased in a rigid suit which contains air at the surface pressure of 14.7 pounds per square inch (psi). Some development was done on suits like this in the 1930's. Recently, much work has been done with the titanium JIM Suit (Figure 1), which is capable of allowing a diver to do functional work in a one atmosphere environment at depths exceeding 1,000 feet.

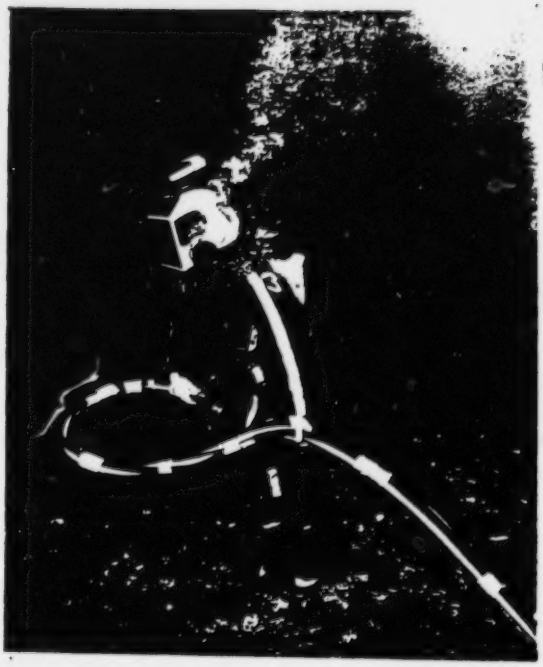
In ambient diving, the diver is subjected to the ambient pressure of the water at the depth at which he is diving. Ambient diving consists of two major subgroups, surface supplied diving and self-contained diving. Surface supplied diving is that mode generally used by commercial diving activities. Self-contained diving uses some form of self-contained underwater breathing apparatus (SCUBA). While primarily used as a sporting activity in terms of numbers of participants, it is widely used in the scientific community for data collection and research support and, to some extent, in the military.

Surface supplied diving is the direct descendant of the "rigid" or Siebe diving dress. Modern hard-hat rigs are similar in appearance to the original Siebe unit. Basically, they consist of a rigid helmet (made of anything from brass to fiberglass) attached to a waterproof suit. Figure 2 shows the more recently developed Navy MK-12 deep diving system and the original MK-5 hard hat rig used for decades. The suit is protected by appropriate one-way valving and is weighted to maintain neutral buoyancy when submerged. Air and communications are brought to the diver through an umbilical line. When diving in a hard-hat rig, the diver originally was considered to be isolated from his environment except for the effects of ambient pressure. These dresses do not provide adequate chemical protection due to their inability to totally isolate the diver from the aquatic environment.

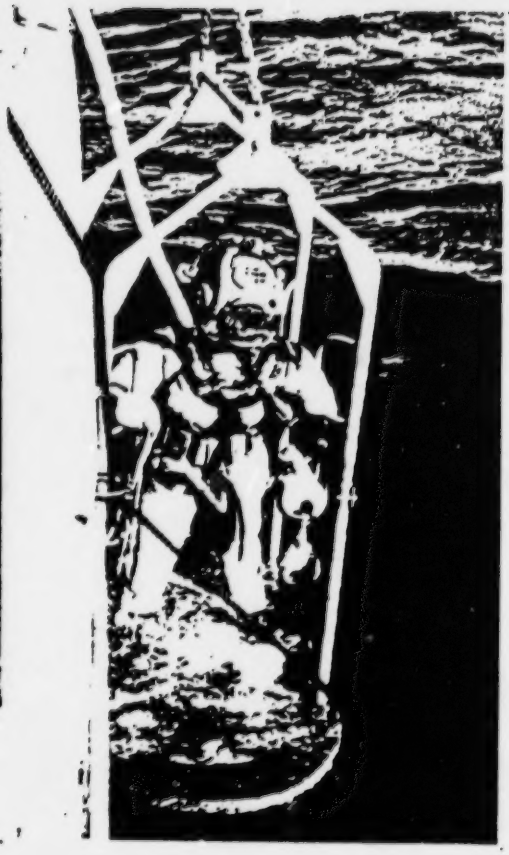
In self-contained apparatus, the diver's air is supplied through a regulator mouthpiece clenched between his teeth. His mouth is constantly exposed to the water. The limitations of standard SCUBA in contaminated waters are obvious. Even if a concerted effort is made to preclude water entry into the mouth, the action of inhalation creates a slight negative pressure making it nearly impossible to keep water out. In addition, the only way a SCUBA diver can clear condensation from inside the mask is to flood it with surrounding water; consequently, the nose and eyes also become exposed to

One Atmosphere "JIM" Suit

Figure 1



New Navy MK-12



Old Navy MK-5

New Navy Mk-12 Surface Supplied Diving System and Former Navy MK-5 Rig

Figure 2

contamination. The standard SCUBA rig simply is inadequate for protecting the SCUBA diver from the effects of diving in contaminated water.

MODIFIED SURFACE SUPPORTED DIVING SYSTEMS

Numerous commercial diving suits and helmets were reviewed for chemical exclusion and material compatability. Five specific diving helmets and six dresses were modified and functionally evaluated at the Naval Underseas Weapons Tower in White Oak, Maryland. A test and evaluation program was also initiated at the existing EPA Oil & Hazardous Materials Simulation Environmental Test Tank (OHMSETT), located in Leonardo, New Jersey. Due to the various complexities of body movements during strenuous diving operations, seals and straps can fail and, thus, cause leakage of contaminants into the diving system. Accordingly, actual dive operations were used to test equipment modifications.

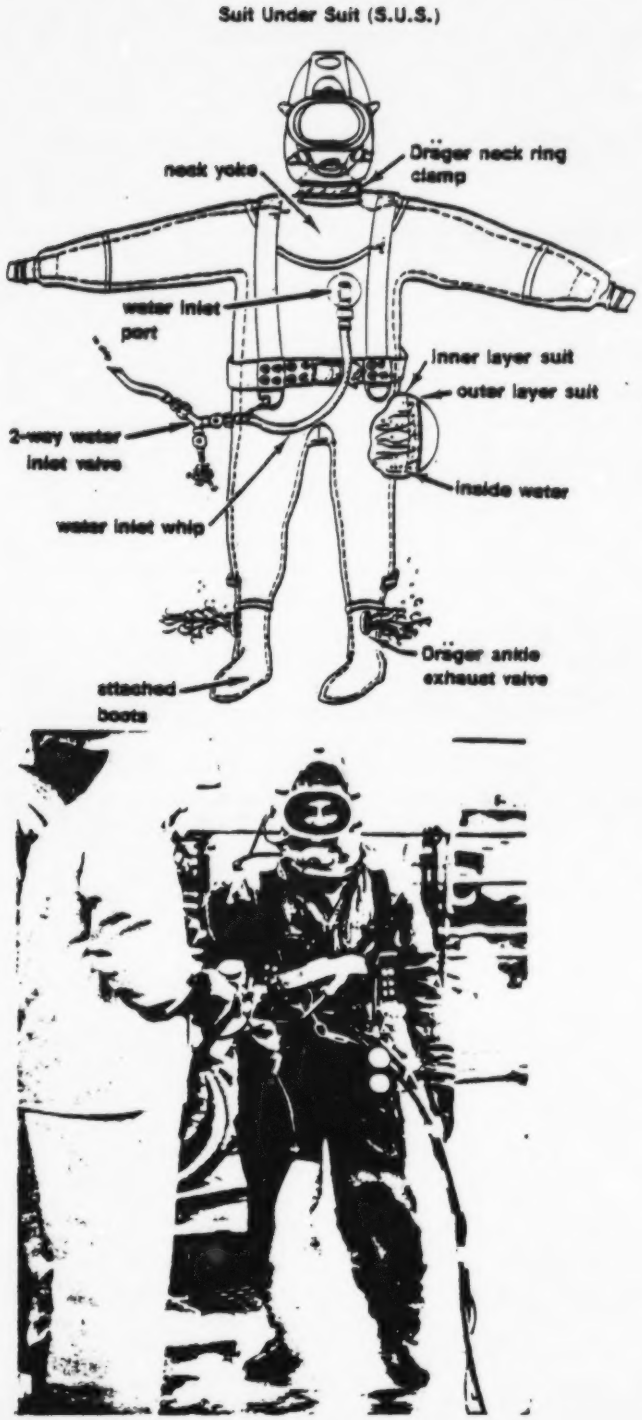
The helmets, which were successfully evaluated for chemical exclusion, were the Draeger Helmet System; the Desco "Pot" Diving Hat; Diving Systems International Superlite-17 Helmet; Morse Engineering MK-12 Navy Deep Water Helmet System; and Safety Sea Systems Helmax Helmet. The six different suit configurations were evaluated along with the above helmets. One diving dress was from Draeger, the remaining five were supplied by Viking Technical Rubber. The Interim Protocol describes the detailed modifications made to each diving helmet and dress. Following are highlights of some of the modifications.

The Draeger Constant Volume Suit, in combination with an undersuit, emerged as a likely candidate for providing adequate protection in polluted water. The standard, off-the-shelf, smooth neoprene Draeger Suit surface can be decontaminated more readily than other foam-type dry suits. The hood fully encloses the diver's head and has a built-in demand regulator and faceplate which seals to the suit at the neck in a simple reliable fashion eliminating the need for a water tight zipper.

Dry suits containing air have significant internal/external pressure differentials, depending on the position of the diver in the water. Since both a pressure differential and a hole are required for entry of water into a dry suit, elimination of one of these factors will preclude entry of outside water. If the inside of a dry suit is filled with water, the internal/external pressure differential can be reduced or eliminated. This same water can be used for diver thermoregulation.

Accordingly, a major modification to the standard Draeger system included a Suit-Under-Suit (SUS) (Figure 3) diving dress. A tight-fitting foam neoprene undersuit with attached feet and neck entry makes up the innermost portion of this system. The neck of the undersuit seals to the neck ring of the Draeger suit. A neck dam provides a seal between the neck ring and the diver's neck. The Draeger suit and hood seal is then worn in a normal fashion over the SUS and neck dam. Clean water is pumped into the area between the SUS and the Draeger suit via an umbilical from the surface, and exits through the exhaust valves near the ankle of the Draeger suit. The neck dam prevents entry of this water into the hood.

The modified suit is filled with water while the diver is at the water surface with his feet in an elevated position to allow the escape of air



Draeger "Suit-Under-Suit" Diving Dress

Figure 3

through the exhaust valves. The diver must exit the water slowly at the end of the dive to allow adequate time for water to drain from the suit. A two-way valve is provided to allow the diver to control the rate of flow through the suit and to provide rapid discharge of pumped water through the hose. The latter is sometimes necessary to maintain proper water temperature.

Test dives with this system proved to be significantly more comfortable for the diver than an air-filled dry suit. No pressure differentials exist, thereby eliminating suit squeeze. Buoyancy changes due to compression and expansion of air and air shifting within the suit are also eliminated.

The Morse Engineering MK-12 Surface Supplied Diving System (SSDS) consists of four major units: the helmet assembly, recircular assembly, dress assembly, and the support equipment (Figure 2). The helmet may be used with air or mixed gas as the breathing medium.

The standard swimming dress consists of either a wet suit or swim trunks with jocking harness, fins, scuba weight belt or outer garment, weights and the neck-dam with exhaust valve in the ambient configuration.

The standard diving dress, for "on-the-bottom" operations, consists of a crushed foam neoprene nylon drysuit, outer chafing garment, jocking harness, lightweight diving boots, and gloves. Two-, four-, and five-pound lead weights (to a maximum of 60 lbs) fit into the calf, thigh, and hip pockets of the outer garment. The outer nylon chafing garment provides protection for the drysuit against snagging, tearing, and abrasion; provides inflation restraint to prevent inadvertent blow-up; has pockets for installing diver weights; and assists in maintaining the jocking harness in place for helmet stability.

The standard MK-12 SSDS diving dress is virtually impossible to decontaminate and does not provide a dry suit/glove interface. Accordingly, Viking Technical Rubber produced two variations of the dress for contaminated water operations.

--The first Viking Chemical Suit model was an exact duplicate of the standard MK-12 outer chafing garment, providing all necessary weight pockets to accept 60 pounds of lead bars, blocks, and rods required for diver buoyancy control, and including compress, calf, and thigh straps to prevent diver "blow-up" or over-pressurization.

--The second model was a smooth dress with no weight pockets or compressive straps and required use of the standard outer chafing garment.

Both Viking suits are made of very heavy weight, 1.1 mm thick, natural rubber bonded onto polyester tricot fabric. The rubber provides waterproofing but no insulation. The diver must wear clothing or insulated underwear for warmth. The wrists of the suits are sealed by stretchy latex cuffs cemented to the suit's arms and then covered with rubber tape but can easily be removed if damaged. Cuff rings made of hard rigid PVC plastic pipe material can be slipped inside the sleeve of each arm allowing for a multiple gloving system. A latex chemical-resistant glove is worn in combination with a cotton work glove to detect leakage from the outer glove and to provide warmth. Over the cotton glove a heavy neoprene rubber glove covered by another outer cotton chafing glove can be added for abrasion resistance. This constitutes a 4

glove system. A thin surgical glove can also be added to provide additional protection.

The Superlite-17 Commercial Diver's Helmet manufactured by Diving Systems International (Figure 4) is constructed of molded fiberglass and weighs approximately 24 pounds dry. Modifications to the Superlite-17 included the use of an exhaust system in which gases exit the helmet through a minimum of two in-line exhaust valves. This system eliminates small amounts of water from back-flushing into the helmet before a single exhaust valve completely closes. Isolation of the second stage diaphram with a brass cap also protects the diaphram from potential contamination. Ambient pressure reference is achieved with a tube running from the brass cap to the inside of the helmet through existing openings previously used for communications.

The Superlite-17 was mated with a specially cut Viking heavy duty commercial dry suit. The collar of the Viking was arranged so that the bottom "toilet" seat collar, or breach ring, was covered by suit material and secured by a drawstring. This created a totally dry seal between the helmet and the suit.

The Helmax SS-20 Model B Helmet, (Figure 4) manufactured by Safety Sea Systems, Inc., resembles a "clam shell" mask with a hinged head protector equipped with locking levers that seal a one-half inch thick stainless steel hood ring between the hull section and the head protector when in the closed and locked position. The mechanical arrangement allows very quick donning and removal of the helmet in either a standing or sitting position. The hull is manufactured from stainless steel as is the head protector frame. The view port is 3/8" thick tuffak (polycarbonate) coated with a permanent anti-fog compound. The system is intended for use with an umbilical that will supply the breathable gas and communication cable.

The Helmax helmet was tested with a specially modified Viking commercial heavy duty dry suit. The attached hood of the Viking received the Helmax helmet ring allowing for a totally dry seal.

The Desco Diving Hat (Figure 4) is simple, rugged, and all-metal. It rests on, and turns, with the diver's head. It has approximately neutral buoyancy under water and its low center of gravity and excellent fore-and-aft balance hold it comfortably and securely on the diver's head in all working positions.

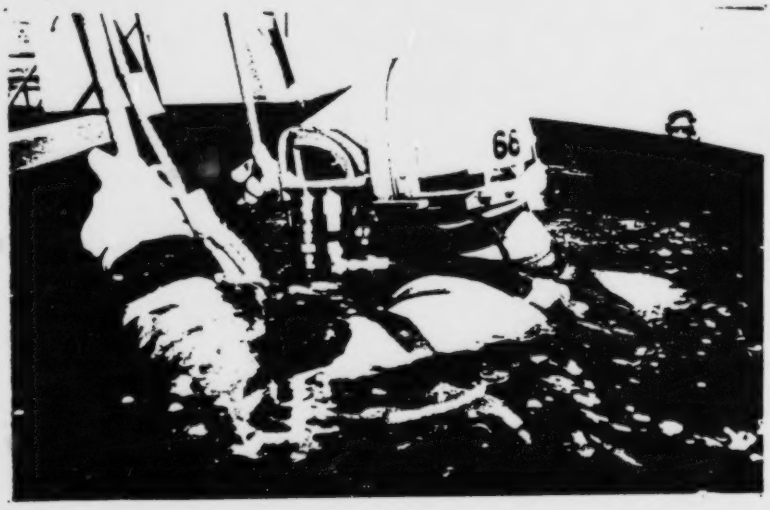
The neck ring seal is of a new and unique design, providing two independent and complementary waterproof seals. It is designed so that the diver can put the hat on or off quickly in close quarters without assistance from a tender and even while wearing heavy gloves.

Unlike the Superlite-17, which is a demand air supply system, the Desco Diving Hat is a free air flow system. Air is continually introduced into the helmet to maintain a positive pressure. The only modification made to this system was the addition of a series exhaust similar to that used in the Superlite-17.

A specially modified Viking heavy duty commercial suit was used with the Desco Hat. The lower breach ring of the helmet provides for a totally dry seal with the Viking suit.

Superlite-17

Desco Pot Helmet



Helmax SS-20

Figure 4

Chemical tank testing of the aforementioned diving ensembles included laboratory analyses of inner suits and helmets for both ammonia and flourescein dye tracer. The modified Desco Pot, Superlite-17, MK-12, Helmax SS-20, all with Viking heavy weight dry suits, and the Draeger SUS dress, successfully isolated the diver from the chemical tracers (4).

HAZARD EVALUATION

Significant contributions to chemical contamination of waterways are spills of petroleum products, hazardous materials, and other miscellaneous materials. From 1977 to 1981, 64,609 such spills were reported to the U.S. Coast Guard Office of Marine Environment and Systems. This represents a total of 75.6 x 10^6 gallons of material released into navigable waterways alone. From 1974 to 1981, 454 large spill or release incidents were reported involving a total of 20.9 x 10^6 pounds of dry hazardous and other substances (4).

The acute toxicity of petroleum products is usually related to the degree of refinement. All types are capable of causing chemical burns in prolonged contact with exposed skin. Products which come in contact with the eyes, mucous membranes, and other sensitive areas of the body (lips, ears, armpit, genital area) have been shown to cause severe burns. Inhalation of fumes will often cause headache, nausea, and stuperous effects. Aspiration of pure product can cause significant lung damage. Ingestion usually causes nausea and can burn the oral-upper gastrointestinal tract. Petroleum products are associated with several documented and suspected chronic effects such as skin irritation, skin cancer, mild aesthetic effects, chemical pneumonitis, central nervous system damage, and blood disorders. There is also a potential for fire and/or explosion with most petroleum products. The variety of hazardous chemicals far exceeds the variety of petroleum products. The properties, toxicity, and other hazards are also much more sophisticated.

Much of the standard reference toxicity data available is based upon "pure product" contact. A diver in an underwater response operation will normally have the beneficial protection of "dilution" as a buffer between him and the pure contaminant. For example, in most large waterbodies, currents, tides, and winds provide for water column "turnover" or mixing. Pure chemical product emanating from a point source, such as a drum, barge, ship discharge line, etc., will undergo dilution even as close as a few feet from its origin. This does not imply that the diver or on-scene-coordinator (OSC) should assume that "dilution is the solution" and accordingly there is no danger.

Slightly soluble and insoluble sinking compounds can accumulate in pockets or bottom depressions under low current conditions. Situations of diver response in the presence of such chemicals (Table 1) requires extra precaution due to the "pure product" condition that can be encountered underwater.

Special precautions should also be exercised by personnel operating in "naturally" polluted waterways which receive treated as well as untreated municipal and industrial waste. Hydrogen sulfide, a by-product of decomposing bottom sediment, is a slightly soluble sinking compound which will accumulate in bottom depressions. A diver can easily enter into such an area without

warning. The material exhibits a very high skin penetration and an extreme systemic hazard. Full encapsulation of the diver is required in such an area while limiting exposure to as short a duration as possible.

Table 1

Slightly Soluble/Insoluble Sinking Compounds

Acetic Anhydride	Acrylonitrile
Bromine	Cresol
Epichlorohydrin	Carbon Tetrachloride
Turpentine	Napthalene
Hydrogen Sulfide	Methylene Chloride
Perchloroethylene	Dichloropropane
Methyl Parathion	Polychlorinated Biphenols
Trichloroethylene	Chlordane

Another group of compounds in which a diver could come into contact with is "insoluble or slightly soluble floating" compounds. These would be at the water surface and could coat the diver upon entry and exit from the operation site. The use of a firehose on the chemical slick will often be enough to disperse the contaminant to enable the diver to safely enter and exit the water. Examples of such compounds are shown in Table 2.

Table 2

Insoluble/Slightly Soluble Floating Compounds

Benzene	Methyl Methacrylate
Styrene	Toluene
Chromium Salts	Ethyl Benzene
Glycol Salicylate	Methyl Ethyl Ketone
Xylene	

In preparing the Interim Protocol, the properties of commonly spilled hazardous chemicals were reviewed. Based upon their behavior in water they were grouped into the following categories:

a. Highly Soluble/Miscible Compounds
b. Slightly Soluble/Slowly Dissolving/Floating Compounds
c. Slightly Soluble/Slowly Dissolving/Sinking Compounds
d. Insoluble/Floating Compounds
e. Insoluble/Sinking Compounds
f. Compounds Which Could React Violently with Water

This grouping is meant to provide guidance for the decision maker on when and how to use divers/ROV's in response situations. Table 3 (4) lists commonly spilled chemicals considered to be of high priority to respective agencies and is presented as an example of the variety of materials a decision maker could be faced with.

In most instances, the use of appropriate encapsulating suits and helmets by diving personnel will allow underwater operations to be conducted in contaminated environments. However, there will be situations where the haz-

ardous substances(s) involved will present such a risk as to preclude the deployment of diving personnel except in extreme emergencies and only for short exposure periods.

With reference to the USCG list in Table 3, and dermal toxicity data presented in the Interim Protocol, umbilical supported encapsulated diver exposure to the following chemicals should be as short a duration as possible, and only in response to protection of public health (e.g., rescue of personnel), or massive environmental damage such as the possible loss of a community's only surface drinking water reservoir:

Cresol	Carbon Tetrachloride
Napthalene	Hydrogen Sulfide
Methylene Chloride	Perchloroethylene
Dichloropropane	Polychlorinated Biphenyls
Trichloroethylene	Benzene
Methyl Methacrylate	Styrene
Toluene	Ethyl Benzene
Xylene	

Examples of insoluble chemical substances in which a diver should never be allowed to operate in are as follows:

Acetic Anhydride	Acrylonitrile
Bromine	Epichlorohydrin
Methyl Parathion	Chlordane

These lists are by no means complete. Classification was based upon material solubility in water and allowable concentrations as found in the EPA Oil & Hazardous Materials Technical Assistance Data System (OHMTADS). Chemicals encountered in the field should be evaluated on the same basis. In addition, the potential impact of the chemical on diving dress materials is currently being evaluated under a USN research contract.

MEDICAL MONITORING

Hazardous incidence response personnel, including divers and surface support personnel, can be exposed to conditions atypical of normal occupational conditions. Special attention should be given when developing medical surveillance programs for these personnel since they can be exposed to thousands of toxic chemicals that may or may not be identifiable at the time of response. Even if the substances are identified, potential health effects from exposure may not be known. The Interim Protocol recommends specific medical examination tests for these individuals.

PROTECTION OF SURFACE SUPPORT PERSONNEL

A major area often overlooked in contaminated underwater diving operations is the protection of surface tenders and support personnel. Previous commercial operations have shown that the recovery of sunken chemical drums and containers can lead to some degree of contamination of the ship's deck and surrounding equipment. Umbilical and line tenders handling divers' support hoses will inevitably come in contact with contaminated water. Appropriate levels of personnel protection must be defined for these special situations.

TABLE 3

COMPARISON OF PRIORITY HAZARDOUS SUBSTANCES IN WATERWAYS

U.S. COAST GUARD POLLUTION INCIDENT DATA BASE	U.S. NAVY CONTRACT N60921-82-D-A052	NOAA HAZARDOUS MATERIALS RESPONSE PROJECT	ENVIRONMENT CANADA
Acetic Acid	Acetyl Chloride	Acetone	Acetic Acid
Acetic Anhydride	Acrylonitrile	Ammonia	Acetic Anhydride
Acetone Cyanohydrin	Aqueous Film Forming Foam	Ammonium Nitrate	Ammonia
Acetyl Chloride	Benzene	Anyhdrous Ammonia	Ammonium Nitrate
Acrylonitrile	1,2-Butylene Oxide	Benzene	Ammonium Phosphate
Aluminum Sulfate	Chlorine	Butyraldehydes	Benzene
Ammonia	Carbon Disulfide	Dichloromethane (Methylene Dichloride)	Calcium Chloride
Ammonium Compound (Nitrate & Sulfate)	Diethylether	Ethanol (Ethyl Alcohol)	Calcium Oxide/Hydroxide
Benzene	DS-2	Hydrochloric Acid (Muriatic Acid)	Carbon Dioxide
Bromine	Ethylamine	Isopropanol (Isopropyl Alcohol)	Chlorine
Carbon Tetrachloride	Ethylene Glycol	Methanol (Methyl Alcohol, wood alcohol)	Cyclohexane
Chlordane	Ethyl Methacrylate	Methyl Ethyl Ketone (MEK)	Ethylbenzene
Chlorine	Formaldehyde	Methyl Parathion	Ethylene Dichloride (1,2-Dichloroethane)
Chromium Compounds (Chromic Salts (CrH) & Chromous Salts (CrCl))	Formic Acid	Perchloroethylene (Tetrachloroethylene)	Ethylene Glycol
Chromium Salts (metals & Insolubles)	Hexane	Phenol	Ethylene Oxide
Copper Compounds (Nitrate & Sulfate)	Hydrochloric Acid	Phosphoric Acid	Ethylene
Cresol	Methyl Ethyl Ketone	Propane (Liquified Propane Gas)	Ferric Chloride
Dichloropropane	Nitrobenzene	Sodium Hydroxide (Caustic Soda)	Formaldehyde
Dimethylamine	Oil, Gasoline	Styrene (Vinyl Benzene)	Hydrogen Chloride/Acid
Epichlorohydrin	Oil, JP-4	Sulfuric Acid (Oleum, Oil of Vitriol)	Hydrogen Fluoride/Acid
Ethyl Alcohol	Organo-Tin Paint	Tetraethyl Lead	Hydrogen Sulfide
Ethyl Benzene	Polychlorinated Biphenyls (50% Solution with Trichlorobenzene)	Toluene (Methyl Benzene)	Mercury
Ethylene Glycol	Sulfuric Acid	Xylenes	Methanol
Glycol Salicylate	Super Tropical Bleach		Morpholine
Hydrochloric Acid	Trichloroethylene		Naphtha
Hydrofluoric Acid			Natural Gas
Lead Acetate			Nitric Acid
Lead Arsenate			Phenol
Lead Chloride			Phosphoric Acid
Lead Nitrate			Phosphorous
Lead Sulfate			Potash (Potassium Chloride)
Lead Tetraethyl			Propylene Oxide
Lead			Propylene
Maleic Acid			Sodium Chlorate
Maleic Anhydride			Sodium Chloride
Methyl Alcohol (Methanol)			Sodium Hydroxide
Methyl Ethyl Ketone			Sodium Hypochlorite
Methyl Methacrylate			Sodium Sulfate
Methyl Parathion			Styrene (Monomer)
Methylene Chloride (Dichloromethane)			Sulfur Dioxide
Naphthalene			Sulfuric Acid (and Oleum)
Nitric Acid			Sulfur
Nitrogen Dioxide			Tetraethyl Lead
Perchloroethylene (Tetrachloroethylene)			Toluene
Phenol			Urea
Polychlorinated Biphenyls (PCB)			Vinyl Chloride
Potassium Permanganate			Xylenes
n-Propyl Alcohol			Zinc Sulfate
Sodium Disulfite			2-Ethylhexanol
Sodium Hydroxide			
Sodium Hypochlorite			
Sodium Sulfide			
Styrene			
Sulfuric Acid			
Toluene			
Trichloroethylene			
Turpentine			
Vinyl Acetate			

Limited deck area does not allow for large "clean areas" for personnel decontamination and changing of self-contained breathing apparatus air tanks. Depending on the toxicity level of hazardous substances, this could dictate the need for airline supplied respirators for surface support personnel functioning in highly-contaminated areas. Also, appropriate considerations and procedures are required for decontamination of surface support personnel. "Clean" locations must be designated for suiting up divers, and procedures must be developed for moving divers and their gear back to decontamination stations. Specific procedures are also required for umbilical, helmet, and diver dress decontamination operations.

SOURCES OF INFORMATION AND RESPONSE ASSISTANCE

In a hazardous spill situation, the On-Scene-Coordinator or the Marine Safety Officer must quickly assess conditions to determine whether or not to deploy diving personnel into contaminated waters. Hazards to surface response workers should also be evaluated.

Numerous sources of information and organizations exist that can provide technical data and physical assistance regarding both the hazards associated with an incident and methods to deal with them. It is necessary to be aware of these resources and to know how to use them.

Information such as topography, meteorology, physical/chemical properties of the spilled material, applicable treatment methods, and available cleanup resources, can be provided by various agencies, maps, reference books, and manuals. It is advisable to get data from at least two sources and use the latest edition of any reference, especially when searching for hygienic standards or toxicological data.

Access to on-line computer files may be possible at a site if a telephone, portable terminal, and 120-volt outlet are available. Aerial photographs can also provide useful information when properly interpreted.

NOAA's Hazardous Materials Response Project (HAZMAT) is a member of one of the groups of special forces available upon request to OSC's for response to actual or potential releases of pollutants, as well as for contingency planning.

The Interim Protocol contains a listing of basic references, on-line computer systems, remote sensing and map interpretation information, and a list of technical assistance organizations.

SUMMARY

The information presented in this paper is meant to highlight some of the considerations for underwater operations involving hazardous chemicals. The Interim Protocol and final MOP address these areas as well as additional areas in much more detail.

The issuance of this "Interim Procedures" document, prior to completion of final field evaluation and demonstration of modified equipment and newly developed response procedures, is needed to serve as a reference guide to safer underwater operations. Field evaluation and shakedown of the

procedures, techniques, and equipment described herein is required prior to the issuance of a complete finalized MOP.

The final MOP will cover general procedural activities related to hazard evaluation, diver deployment and recovery, surface tending operations, and equipment decontamination procedures.

Safety is the prime concern in any underwater operation, be it deep saturation diving on exotic gases or the need to effect a chemical drum recovery operation. With the help of the scientific community, military organizations and commercial industry, the justifiable deployment of diving personnel in heavily chemically polluted waters can be safely and effectively accomplished.

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